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Cpy To Turk Dec. 1972

EFFECTIVENESS OF LINDANE AND BENZENE HEXACHLORIDE IN USE AGAINST BARK BEETLES AND WOOD BORERS

by

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This ms. is part of a PSW Res Rev. Paper which is in press; the whole paper deals with all aspects of lindane; this ms. deals only with efficacy

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SUMMARY

There is very strong evidence in the literature that lindane or benzene hexachloride is effective as a remedial and as a preventive treatment against many species of bark beetles: western pine, mountain pine, black turpentine, southern pine, Douglas-fir, and Engelmann spruce beetles, and several species of Ips and Scolytus. Hosts include: slash, loblolly, ponderosa, sugar, lodgepole, white and red pine, and Douglas-fir, Engelmann spruce, and elm. Formulations range from 0.25 to 3.0% as oil solution or aqueous emulsion; dosages per gallon ranged from about 50 to 200 sq. ft. of bark. Population reductions within the materials treated range from 80 to 100%. Prophylactic action persists for up to 3 years. BHC (gamma) is also effective against cerambycid, buprestid, and ambrosia beetles, as well as against powder-post beetles, old-house borers, subterranean and non-subterranean termites, in general, being effective for 3 to 7 years.

INTRODUCTION

This is a review of articles on the field effectiveness of lindane and the gamma isomer of benzene hexachloride (BHC) in controlling bark beetles, borers, and other wood-feeding insects. Though it is not an exhaustive review, it does cover a wide variety of insects, host trees or materials, and formulations over a long period of time, in widely separated areas. It should be noted in particular that, in every instance of use, the insecticide was highly restricted to narrowly defined targets such as individual trees, logs, and wood products. There were no broadcast applications.

Test results for each species or group of bark beetles can be divided into remedial and preventive types. In remedial tests, the insecticide was applied to infested material and an assessment of results made by failure to emerge and/or by reduced longevity or capability, such as boring and oviposition, after emergence. In preventive tests the insecticide was applied to uninfested trees or logs and then exposed to attack at varying times afterwards. Dosage was expressed in various ways but most often as square feet per gallon or to "wetness" or "runoff"; these last two can be converted to one-gallon for approximately 100 and 50 sq. ft. of bark surface respectively. Diesel oil was the usual carrier for oil solutions; aqueous emulsion was always the form of emulsion used. Much of the early work was with the gamma isomer, one of five isomers, of benzene hexachloride, BHC; more recent tests used lindane, which is the trade name for the pure gamma isomer. In tests with BHC(g), some of the other isomers were present in the spray material. However, the two--lindane and BHC--produce essentially the same results.

Some of the early testing of lindane with bark beetles utilized a topical application procedure; much of that work has been reviewed by Lyon (1965). In his studies with western pine beetle, mountain pine beetle, fir engraver, and Ips engraver, he found lindane often superior to most other chlorinated hydrocarbons. He used the term "uncommonly toxic" to sum up his findings.

The material which follows is arranged by insect species or commonly associated groups of insects. Under each insect, or group, the results are broken down into remedial tests and preventive tests as defined above. Dosage, unless otherwise specified, is for square feet of bark.

Western Pine Beetle (*Dendroctonus brevicomis* Lec.)

Field tests were all with ponderosa pine (*Pinus ponderosa* Laws.) in California

Remedial

1. 92% brood reduction--failure to emerge plus mortality 3 days after emergence--resulted from 1.5% lindane in diesel oil, presumably at one gallon per 100 sq. ft.; spray applied just prior to the start of emergence (Lyon and Wickman 1960).
2. 87 to 99% brood reduction--failure to emerge plus 3-day mortality--resulted from 1.5% lindane emulsion against overwintering brood. Spray applied to wetness 1 to 5 months prior to emergence. Variation in percentage largely attributable to time of application (Lyon and Swain 1968).

Preventive

1. 100% effectiveness obtained for 12 months and 3 months by 2.5% lindane oil and emulsion, respectively, at one gallon per 50 sq. ft. (Smith 1967).
2. 74% effectiveness obtained for 7 months by 1.3% lindane emulsion applied to fire-damaged ponderosa pine; no dosage given. Reduction in subsequent tree mortality varied from 50 to 100%, depending on amount of fire damage (Swain 1968).
3. 99% effectiveness obtained for 36 months and 22 months by 2.0% lindane oil and emulsion, respectively, at one gallon per 50 sq. ft. (Smith 1970).

Mountain Pine Beetle (*D. ponderosae* Hopk.)

Field tests were with both ponderosa and lodgepole pine (*P. contorta* Dougl.) in California and with ponderosa in Colorado.

Remedial

1. 90% of the brood was killed in lodgepole pine by 1.5% lindane in oil applied 1 to several weeks before emergence, presumably at one gallon per 100 sq. ft. Though some trees were missed, the subsequent infestation was reduced to 25% of its former level on an 85-acre plot (Wickman and Lyon 1962). [Author's note: In an infestation of this type, it is assumed that the infestation level will be maintained if not treated (Evenden and Gibson 1940; Struble and Johnson 1955)].
2. 92 to 97% brood reduction--failure to emerge plus 3-day mortality--resulted from 0.5 or 1.5% lindane emulsion, respectively, applied to wetness about 2 months before emergence from ponderosa pines (Stevens and Mitchell 1970).

Preventive

1. 100% effectiveness obtained with 2.0% lindane oil solution for 36 months, and 91% with a 2.0% emulsion for 22 months on ponderosa pine at one gallon per 50 sq. ft. (Smith 1970).

Black Turpentine Beetle (*D. terebrans* [Oliv.])

Field tests were with slash (*P. elliotti* Engelm.) and loblolly (*P. taeda* L.) pine in Florida, Mississippi, and Louisiana.

Remedial

1. 82 to 89% brood reduction obtained in slash pine stumps with .5% BHC(g) in oil, and 59 to 68% with .5% BHC emulsion, when applied at one gallon for 50 sq. ft. several weeks before emergence (Smith 1956).
2. Inconclusive results were obtained on loblolly pine in Louisiana when a 1.0% BHC oil solution was applied to runoff to 1-month-old stumps in a 2,000-acre cutting area. Two-thirds of the area was treated; one-third was untreated (Kucera *et al.* 1970).

Preventive

1. 100 and 98% effectiveness obtained with .5% BHC in oil for 4 months and 7 months, respectively, on slash pine at one gallon per 50 sq. ft.; 69% with .5% emulsion for 7 months (Smith 1954).
2. 100% effectiveness obtained with 0.5% BHC oil on slash pine for 17 months at one gallon per 50 sq. ft. About 10% of untreated trees were attacked and killed; no treated trees were attacked (Smith 1956).

Preventive and Remedial

1. 90% effectiveness obtained in reducing the incidence of attack on untreated, previously unattacked slash pine and 75 to 80% effectiveness in reducing subsequent tree mortality where trees were sprayed within 1 month after being attacked, with 1.0% BHC in oil at one gallon per 50 sq. ft.; test was maintained over an 18-month period (Smith 1958).

Southern Pine Beetle (D. frontalis Zimm.)

Remedial

1. 97% brood reduction--failure to emerge plus mortality at 16 hours--resulted from both a 1.0% BHC emulsion and a 0.5% oil applied to runoff to bark of loblolly pine 1 to 12 weeks before emergence in summer; 97 and 81%, respectively, with the oil and emulsion in winter applied 12 to 16 weeks before emergence (Bennett and Pickard 1966).

Engelmann Spruce Beetle (D. rufipennis Kirby)

Remedial

1. 93% reduction in subsequent attack capabilities was obtained with 0.5% BHC emulsion; no dosage was given but presumably between wetness and runoff. Effects were determined by individually caging green logs with sprayed and unsprayed Engelmann spruce (Picea engelmannii Parry) stumps in Colorado and measuring subsequent oviposition (Massey and Wygant 1954).

Douglas-Fir Beetle (D. pseudotsugae Hopk.)

Preventive

1. 100% effectiveness over a 20-week period was obtained with 200 mg. of lindane in oil/sq. ft. applied to fresh-cut Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) logs. As an emulsion or suspension, this same dosage was 100% effective for about 10 weeks and 99% for 20 weeks (Rudinsky et al. 1960).

Ips Engraver Beetles (*Ips* spp.)

Remedial

1. 100% brood reduction--failure to emerge plus 3-day mortality--of *Ips confusus* Lec., the five spined California engraver, in ponderosa pine in California obtained with 1.5% lindane in oil (Lyon and Wickman 1960).
2. 89% reduction in longevity of emerged *I. confusus* brood from ponderosa pine and 84% from sugar pine was obtained with 3.1% lindane in oil in California. In addition, there was 75% reduction in emergence from ponderosa and 85% from sugar (Stark and Borden 1965).
3. 98 to 99% reduction in emergence of *I. pini* from red pine in Canada was obtained by 0.5% emulsion sprayed to runoff 4 to 5 weeks prior to emergence (Thomas 1970).

Preventive

1. 99% effectiveness against *Ips* spp. was obtained for 4 weeks in Florida with 0.5% BHC emulsion at 0.4 gal. per 100 sq. ft. of longleaf (*P. palustris* Mill.) and loblolly pine logs (Hetrick and Moses 1953).
2. 90 to 100% reduction in egg gallery length of *I. lecontei* Sw. was obtained in ponderosa in Arizona by 1% lindane emulsion, 85% reduction with 0.5%, and practically no reduction by 0.25% (Ostmark 1969).
3. 100% effectiveness was obtained against *I. pini* (Say) in red pine (*P. resinosa* Ait.) with a 0.5% lindane emulsion applied to runoff a week prior to emergence of brood in the area (Thomas 1970).

Scolytus Engraver Beetles (*Scolytus* spp.)

Remedial

1. 85 and 94% reduction in emergence of *S. multistriatus* Marsh. was obtained with 0.5 and 1.0% lindane emulsion, respectively; spray applied to runoff to American elm (*Ulmus americana* L.) in Connecticut in early spring; a late spring test showed only 78 and 72% (Doane 1958b).

Preventive

1. 96 and 84% reduction in the feeding activity associated with disease transmission at 4 and 13 weeks, respectively, was obtained against *S. multistriatus* with 1% lindane emulsion applied to runoff to American elm; 0.5% was ineffective (Doane 1958a).

Ambrosia Beetles

All tests were preventive.

1. 60 to 100% effectiveness obtained with 0.25% BHC oil on southern hardwoods. Insecticide applied as an instant dip which is comparable to runoff; *Xyleborus affinis* Eich. and *Platypus compositus* Say were the most common beetles (Kowal 1949).
2. Highly effective protection was obtained for 3 to 4 months with 0.5% BHC oil at one gallon per 100 sq. ft. on southern hardwoods (Johnston 1952).

3. 95 to 100% protection obtained with any concentration greater than 0.1% BHC of either oil or emulsion, dosage not given, on red and white pines (P. strobus L.) in Massachusetts. Sprays were applied in the spring and exposed to attack until autumn (Becker 1955).

4. 100% protection for 20 weeks with 200 mg./sq. ft. of Douglas-fir bark, as an oil. As an emulsion or suspension, the same dosage was 100% effective at 8 to 10 weeks and 99+% at 20 weeks (Rudinsky 1960).

Borers (Buprestidae and Cerambycidae)

Remedial

1. 99% brood reduction of Melanophila californica Van Dyke--failure to emerge plus 22-hour mortality--was obtained with 1.5% lindane in oil applied to wetness to Jeffrey pine (P. jeffreyi Grev. & Balf.) from 1 to 6 months prior to emergence; log time between treatment and emergence had no effect on results (Swain and Wickman 1967).

Preventive

1. 99+% effectiveness was obtained against cerambycids for 4 weeks on cut logs of slash, loblolly, and longleaf pine with 0.5% BHC emulsion at 0.4 gal. per 100 sq. ft. of bark (Hetrick and Moses 1953).

2. 100% effectiveness obtained against cerambycids on logs of red and white pine with > 0.1% emulsion BHC; there was 95% effectiveness with 0.1% but a rapid dropoff with concentration below 0.1%; dosage not given. Spraying decks of logs was slightly less effective (Becker 1955).

3. 100% effectiveness against buprestids was obtained for 20 weeks with 200 mg. lindane in oil/sq. ft. of cut logs of Douglas-fir (Rudinsky 1960).

Miscellaneous Wood Feeders

All tests were applied as a preventive to wood except for subterranean termites where soil treatments were used.

1. 100% effectiveness was obtained against a powder post beetle (Lyctus planicollis Lec.) for 3-1/2 years--the length of the test--with a 0.5% BHC oil dip with seasoned oak and hickory; an emulsion was about equally as effective applied to seasoning wood (Johnston et al. 1955).
2. 100% effectiveness was obtained against subterranean termites for 6 years with a 0.4% BHC oil applied at the rate of 2-1/2 gal./10 cu. ft. of soil in Mississippi; 70% effectiveness at 9 years (Johnston 1958).
3. Lindane at 0.5% in oil as a brush or spray is recommended for prevention of old-house borer attacks (Hylotrupes bajulus L.) (McIntyre 1961).
4. BHC at 0.4% in oil recommended for remedy of drywood termite infestations (Snyder 1950).

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